Hunter-Gatherers and the Archaeology of Discard Behavior: An Analysis of Surface Stone Artifacts from Sturt National Park, Western New South Wales, Australia

SIMON HOLDAWAY, JUSTIN SHINER, AND PATRICIA FANNING

SURFACE SCATTERS OF STONE ARTIFACTS FORM THE BULK of the archaeological record in Australia, yet for all their ubiquity, they continue to pose serious problems for archaeologists. Surface deposits lack stratigraphy in the conventional sense, hence it is difficult to assign them an age and more difficult still to use surface material to demonstrate change. They often represent long periods of deposition and spatial proximity is no guarantee of synchrony. Where artifacts can be dated directly (e.g., the heat-retainer hearths discussed in the example below), hundreds of years may separate spatially adjacent features. Some techniques exist for separating artifacts relating to specific events or occupations (refitting is an obvious example, Close 2000), but such techniques are limited in application and in interpretative potential: the *inability* to refit artifacts cannot be taken as an indication of great time depth. In the vast majority of cases, it must be assumed that an assemblage from a surface deposit could have derived from more than one, and often many, separate events or occupations.

This poses a problem for conventional interpretations of surface artifact scatters as representative of past settlement systems. As the contributors to the Rossignol and Wandsnider (1992) volume note, simple functional ascriptions applied to surface artifacts scatters gloss over a range of mechanisms by which artifacts are clustered in the landscape. Over a number of years, ethnoarchaeological studies of mobile peoples (e.g., Binford 1978, 1980; O'Connell 1987; Yellen 1977) have demonstrated that place use is not constant and redundant. Instead, locations in the landscape may be used by a variety of people, in a variety of ways, and at a variety of times. Thus, archaeological sites are not the same as "residential camps" or "extraction sites"; instead, they are palimpsests—or more correctly "aggregates" (Dewar and McBride 1992), since a palimpsest implies the removal of a

Simon Holdaway is a senior lecturer at the Department of Anthropology, University of Auckland; Justin Shiner is a Ph.D. candidate at the Department of Anthropology, University of Auckland; and Patricia Fanning is a senior lecturer at the Graduate School of the Environment, Macquarie University, New South Wales, Australia.

Asian Perspectives, Vol. 43, No. 1

previous record (Wandsnider and Camilli 1996)—at best representing remnant settlement patterns that reflect multiple uses over time.

In Australia, there are two main approaches to interpreting the surface artifact scatters that parallel approaches elsewhere in the world (Holdaway and Wandsnider 2004). One is to use ethnographic observations to develop a settlement system approach, obtaining small samples of artifacts from a large number of locations in the landscape and relating these to the natural environment (e.g., in the arid zone, the permanency of water) or the cultural environment (e.g., Ross 1981; Smith 1989, 1996; Thorley 1998, 2001; Veth 1989, 1993). A second approach is to emphasize technology rather than assemblage location, adopting a behavioral ecological approach to artifact form and incorporating a consideration of access to raw material (e.g., Hiscock 1994). A few studies have attempted to combine both approaches (e.g., Barton 2001).

The difficulty of assigning artifacts a date is nullified in these approaches by assuming continuity when technology is stable. Working in the Rudall River region of northwest western Australia, Veth (1993:78) proposes that both settlement location and subsistence behavior are governed by a seasonal pattern of resource exploitation (mainly influenced by rainfall) and a flexible cycle of aggregation and dispersal. Stone artifact assemblage composition is argued to reflect the relationship between occupation duration and water permanency and it is assumed that this human behavioral-environmental interaction remained stable for a long period of time despite indications of considerable environmental variability during the last 7000 years, including a major dry period between 4000 and 2000 B.P. (Veth 1993:9). Veth states:

> ... to legitimately apply the predictive model here, within an archaeological context ... it is necessary to assume that the settlement-subsistence system has remained broadly similar since the earliest demonstrable date for occupation; in the study area this is 5000 B.P.... (Veth 1993:80)

Similarly, in the Palmer River catchment in central Australia, Thorley (1998:288) uses typological continuities to argue that because there are low numbers of backed blades in surface assemblages in comparison to their abundance in older rockshelter deposits, the surface deposits may be treated as broadly contemporaneous. He goes on to investigate the settlement-subsistence systems these sites represent without investigating chronology on a site-by-site basis (Thorley 1998:309). Barton (2001) working in the Simpson Desert, argues for an approach based on behavioral ecology that ignores time altogether. He assumes that the patterns represented by the abandoned stone artifacts reflect aspects of a constant adaptation in place over thousands of years.

Our interest in the problem of interpreting surface artifact scatters comes from a fieldwork project conducted from 1996 to 1998 at Stud Creek in western New South Wales. Stud Creek is one of a number of ephemeral stream systems in the Mt. Wood Ranges of Sturt National Park near Tibooburra (Fig. 1). It was chosen for detailed study because there were abundant stone artifacts lying on the eroded surface of the valley floor, and the remains of many heat-retainer hearths were clearly visible (Holdaway et al. 2000). Charcoal excavated from the latter could be used for radiocarbon dating, thus providing a temporal framework for the study (Holdaway et al. 2002). In addition to archaeological recording, an inten-

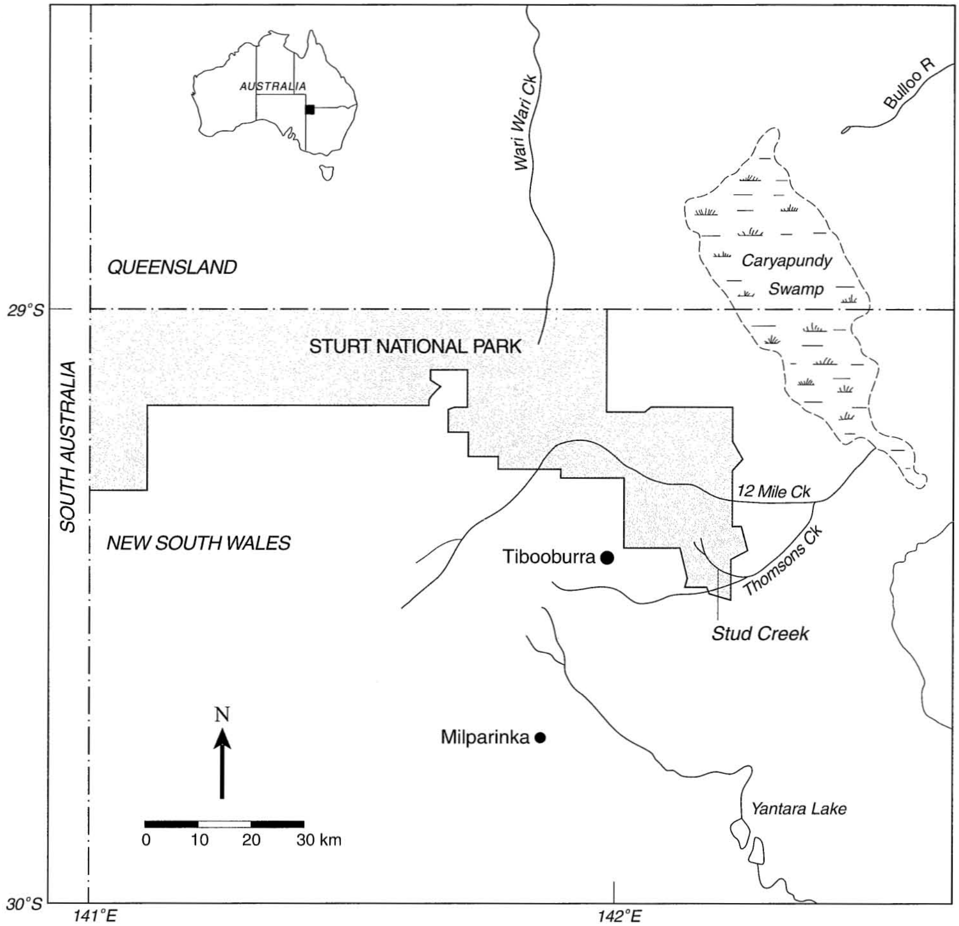


Fig. 1. Location of the Stud Creek study area in northwestern New South Wales, Australia.

sive geomorphological study was undertaken aimed at developing a chronology of landform change within the Stud Creek catchment (Fanning 2002; Fanning and Holdaway 2001*b*).

It is the results of the geomorphological study, and that of the hearths, that forced us to re-evaluate the conventional approaches to surface artifact scatters in Australia, since our results demonstrated neither a uniform past environment nor a stable human response to this environment. This paper presents the results of this re-evaluation. We begin by briefly reviewing the geomorphological and dating studies, then go on to develop an alternative technological approach to stone artifact assemblage analysis inspired by the work of Wandsnider (1996; Wandsnider and Camilli 1996). After reporting the results of an analysis of approximately 50,000 stone artifacts from Stud Creek, we conclude by assessing the significance of our approach for studies aimed at reconstructing human land-use patterns in the past.

THE STUDY AREA

The Stud Creek area of Sturt National Park in far northwestern New South Wales (Fig. 1) lies on the margin of the arid interior of Australia, with annual rainfall averaging 180 mm and pan evaporation exceeding 2000 mm. The dominant vegetation type is chenopod shrubland, with scattered trees (*Acacia* sp.) along the ridges and ephemeral watercourses. Silcrete outcrops form high points in the landscape (mesas and escarpments) and silcrete gibbers (stones) mantle the hill slopes below (Doelman et al. 2001; Witter 1992). The valley floors contain alluvial valley fills of late Pleistocene to Holocene age into which ephemeral streams have incised (Fanning 1999). Scattered across these fills are many thousands of stone artifacts together with dozens of heat-retainer hearths.

Geomorphological Context

A model of post-European landscape change in western New South Wales (Fanning 1999) helps to explain the surface exposures of stone artifacts and hearths at Stud Creek. Large numbers of European animals, notably sheep and rabbits, were introduced to Australia late in the nineteenth century. These, combined with drought conditions in the 1890s, reduced vegetation cover and changed the hydrogeomorphic balance, reducing infiltration and increasing surface runoff when the drought broke. Topsoil erosion from the slopes ensued, with the material deposited as a distinctive sedimentary unit, the "post-European material" (PEM) (Fanning 1999). Subsequently, valley floors destabilized, particularly those in the uplands, leading to partial stripping of the PEM and the formation of scalded and lagged surfaces over extensive areas. As a result, artifact scatters on the lower hill slopes and valley floors were exposed as gravel lags.

The surface archaeological record is thus partly the result of processes that operated in the past but also a function of contemporary, local scale geomorphic processes. To study these we developed a stratified survey strategy (Fanning and Holdaway 2002, 2004). At the regional level, we use available Land Systems mapping, primarily defined using remotely sensed data (i.e., airborne and satellite imagery) to provide a convenient means of assessing which parts of a region are most likely to exhibit maximum artifact preservation. At a second or mesoscale level, smaller landform units that make up the Land Systems become the focus, reflecting the operation of geomorphic processes that affect artifact exposure over contemporary to historic time scales. Standard aerial photograph interpretation and field survey methods are used to map landform elements and classify them on the basis of dominant geomorphic environment, i.e., residual, transportational/eroding, fully lagged, or depositional. In this way, the physical landscape is subdivided on the basis of both landform and dominant process. Finally, a third or microscale level within the survey method concentrates on documenting local variability in land surface condition that reflects the operation of processes with a short time scale of perhaps hours to days. Such processes affect artifact visibility at the time of the field survey, and include local erosion and deposition of sediments, bioturbation, and vegetation growth. The three survey scales are integrated within a vector GIS (Fanning and Holdaway 2002).

Rill and gully erosion has certainly disturbed the integrity of part of the artifact "blanket" at Stud Creek by moving some artifacts down slope, away from their original resting places (Holdaway et al. 1998: Table 3; Pigdon 1997). However, statistical analysis of relationships between artifact size and topographic factors demonstrates that outside of the rills and gullies, little lateral disturbance can be detected (Fanning and Holdaway 2001*a*). A similar result is indicated by refit studies of stone artifacts (Greenwood 1997). Studies of differential artifact visibility indicate a more complex picture (Fanning and Holdaway 2004). As might be expected, sand, sediment, and vegetation limits visibility while artifacts occur more abundantly on gravel patches. However, these factors alone are not sufficient to account for patterns of differential artifact density. Much of the pattern we see today likely reflects the aggregate of differential activity in the past.

Landscape History

A detailed, dated, sedimentary history was constructed for Stud Creek by excavating a 4-m-deep trench adjacent to the current stream channel, with smaller channel bank excavations undertaken at other locations (Fanning and Holdaway 2001*b*). Five main sedimentary units were defined, the uppermost identified as PEM, deposited after European occupation of the region (Fig. 2). In some locations, the PEM abruptly overlies brown, weakly pedal silty clays with abundant evidence of bioturbation (in the form of fine charcoal and roots). This material is interpreted to be a former floodplain surface that existed prior to European occupation. A sample of sediment from near the top of the unit was dated at 2040 ± 100 B.P. (OxL-1050) using optically stimulated luminescence (Fanning and Holdaway 2001*b*). In other locations, this floodplain layer has been removed and the PEM abruptly overlies poorly sorted gray/brown gravely, sandy mud deposited in a series of relatively stable pools. Six radiocarbon determinations date this unit between 4200 and 4600 B.P. (around 5000 cal. B.P.) (Fanning 1999; Fanning and Holdaway 2001*b*). Below are red sandy gravels forming an almost continuous unit across the valley. Two AMS determinations returned results of 5939 ± 60 B.P. (NZA-8959) (6910–6630 cal. B.P. at two sigma) near the top of the unit, and 12,452 ± 68 B.P. (NZA-8960) (15,450–14,150 cal. B.P. at two sigma) near the middle, and a single OSL determination near the bottom of the unit returned an age of 48.12 ± 2.05 ka B.P. (OxL-1055) (Fig. 2). The most parsimonious explanation for the time depth represented by the RSG unit is that broadly similar sediments were laid down in depositional environments over many thousands of years (Fanning and Holdaway 2001*b*: 97). A single OSL age of 75.28 ± 3.35 ka B.P. (OxL-1056) from below the RSG unit is interpreted as a minimum age for the basal unit of cemented gravely sands (Fanning and Holdaway 2001*b*: Table 7.2).

These results indicate that the sediments into which the stone artifacts at Stud Creek were deposited, and from which they have been lagged, are certainly no older than 6–7000 years, and probably a lot younger, perhaps as young as 2000 years. This provides a terminal age for the Stud Creek archaeological deposits, and as discussed below, this age ties in well with the radiocarbon determinations from heat-retainer hearths.

While the sedimentary record from Stud Creek Valley fill is much longer than the archaeological chronology, it is important for the picture it provides of a changing geomorphic environment. It is clearly a discontinuous record, reflecting

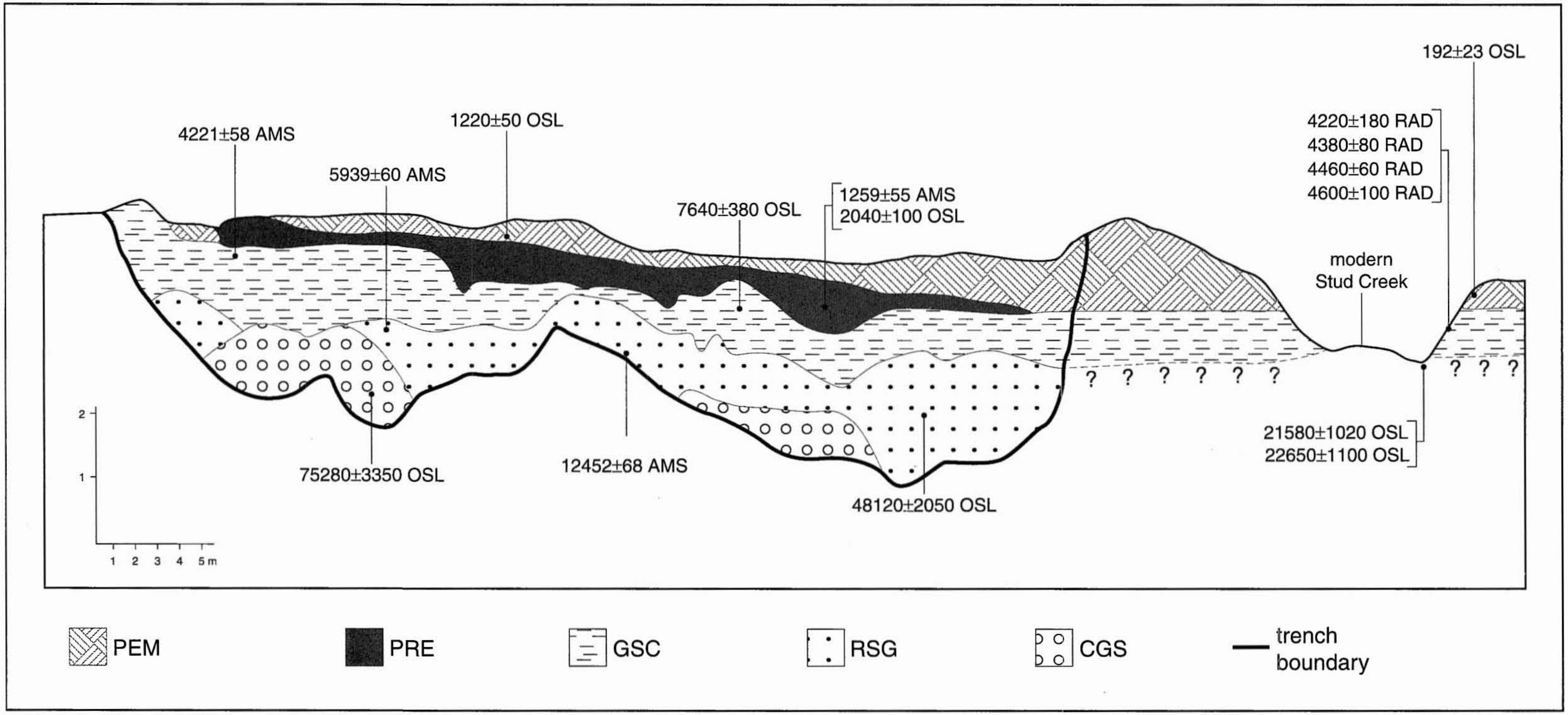


Fig. 2. Stratigraphy of the Stud Creek Valley fill. Approximate positions of samples retrieved for dating are indicated (RAD = radiocarbon; AMS = accelerator mass spectrometry; OSL = optically stimulated luminescence).

limited sediment supply and dominated by erosion. Unstable or disequilibrium conditions over the valley floor predominated from the late Pleistocene through to the mid- to late Holocene (Fanning 2002). This means that it is unlikely that evidence of Indigenous Australian occupation in Stud Creek before the last 2000 years has survived. However, the discontinuous nature of geomorphic processes means that in areas away from Stud Creek, surfaces and their associated archaeological deposits may show a quite different chronology. For instance, isolated deposits dating to the late Pleistocene have occasionally been recorded (e.g., the JSN site in the Strezlecki Desert [Smith et al. 1991], isolated hearths along the Coopers Creek [Veth et al. 1990], and a heat-retainer hearth at Lake Yantara 60 km south of Stud Creek with a radiocarbon determination of 26,200 ± 1100 B.P. [Dury and Langford-Smith 1970]). Given this temporal variability, we argue that it is not reasonable to interpret surface scatters that may be hundreds or even thousands of years apart in age as evidence for the existence of a common settlement system. Our results suggest that new approaches are needed to the study of human land use in the past.

Hearth Dating

At Stud Creek and adjacent areas, radiocarbon determinations for 28 hearths were obtained (22 of these from Stud 1, Stud 2, and Stud Systematic, Table 1). Bayesian statistical analysis indicates that the dates fall into two groups, separated by a period of at least 200 years, and possibly 500 years, when no detectable hearths were created (Holdaway et al. 2002). The first of these groups is bracketed by Wk-6632 (220 ± 55) and Wk-5329 (820 ± 50) giving a duration for hearth construction with a 68 percent probability distribution of 580–720 years and a 95 percent probability of 500–810 years (Holdaway et al. 2002: Fig. 7). For the second group, bracketed by Wk-6629 (1170 ± 130) and Wk-6130 (1630 ± 50), the estimated duration of hearth construction is 680–850 years at 68 percent probability and 600–970 years at 95 percent probability (Holdaway et al. 2002: Fig. 8). While it cannot be directly demonstrated, it is likely that many of the stone artifacts found at Stud Creek were deposited during the two phases of hearth construction.

Comparison of the hearth chronology from Stud Creek with palaeoenvironmental records for late Holocene Australia suggests an explanation for the gap in hearth construction. The period during which no hearths were constructed matches closely the period of climatic change termed the Medieval Warm Period, during which the climate became warmer and drier (Holdaway et al. 2002). Although the small sample from Stud Creek is insufficient evidence from which to determine whether Indigenous Australian people responded to climatic change by abandoning only the Stud Creek Valley, the Stud Creek and adjacent drainage systems, or indeed the entire western region of New South Wales, it is sufficient evidence to question models that posit continuity in human-environment interrelationships.

Thus, studies at Stud Creek indicate that surface artifact scatter preservation reflects geomorphological processes rather than simply locations used as part of a common settlement system. Artifact scatters that may appear to be superficially similar located outside the upper Stud Creek catchment may in fact be many hundreds or even thousands of years apart in age. Equally, analysis of Stud Creek

Table 1. Radiocarbon Determinations for Charcoal from Stud Creek Hearths

LAB NO.	LOCATION	SAMPLE WEIGHT (G)	CONVENTIONAL RADIOCARBON AGE (B.P.)	CALENDRIC AGE AND PROBABILITIES AT 2 STD. DEV. (CAL. B.P.)
Wk-6621	Stud 1	10.40	380 ± 50	314–410 (0.515) 419–511 (0.431)
Wk-5332	Stud 1	15.15	470 ± 50	332–354 (0.036) 433–557 (0.88) 606–623 (0.033)
Wk-5127	Stud 1	5.82	580 ± 60	518–654 (0.952)
Wk-5125	Stud 1	15.06	660 ± 50	549–673 (0.953)
Wk-6631	Stud Systematic	3.38	660 ± 50	549–673 (0.953)
Wk-5330	Stud 1	10.10	690 ± 50	552–610 (0.013) 620–696 (0.548) 699–708 (0.388)
Wk-6624	Stud 2	3.15	720 ± 55	557–606 (0.74) 623–736 (0.209)
Wk-6038	Stud 2	7.00	790 ± 50	654–792 (0.01) 815–824 (0.938)
Wk-5329	Stud 1	15.04	820 ± 50	665–795 (0.069) 812–829 (0.037) 863–906 (0.848)
Wk-6629		1.95	1170 ± 130	793–814 (0.913) 826–868 (0.025) 883–1309 (0.014)
Wk-5124	Stud 1	10.11	1210 ± 50	994–1030 (0.879) 1053–1262 (0.07)
Wk-5122	Stud 1	15.08	1260 ± 40	1070–1113 (0.697) 1119–1161 (0.14) 1168–1283 (0.114)
Wk-5126	Stud 1	8.89	1260 ± 60	1058–1291 (0.948)
Wk-6622	Stud 1	4.85	1280 ± 60	1064–1293 (0.951)
Wk-6036	Stud 2	10.70	1290 ± 50	1079–1112 (0.806) 1120–1161 (0.084) 1168–1294 (0.056)
Wk-5331	Stud 1	15.10	1300 ± 50	1085–1111 (0.853) 1122–1160 (0.062) 1168–1304 (0.036)
Wk-6037	Stud Systematic	5.90	1310 ± 60	1068–1116 (0.806) 1120–1161 (0.858) 1168–1391 (0.048) 1401–1407 (0.034)
Wk-6623	Stud 1	2.01	1350 ± 75	1079–1112 (0.005) 1117–1162 (0.077) 1168–1310 (0.067)
Wk-6620	Stud 2	3.50	1390 ± 70	1149–1156 (0.003) 1171–1418 (0.005) 1471–1481 (0.939) 1504–1510 (0.003)
Wk-5123	Stud 1	7.16	1410 ± 50	1240–1246 (0.94) 1261–1411 (0.007)
Wk-6039	Stud Systematic	5.70	1440 ± 60	1263–1420 (0.015) 1433–1444 (0.038) 1449–1486 (0.01)
Wk-6035	Stud 2	10.30	1460 ± 50	1287–1419 (0.014) 1434–1443 (0.023) 1451–1459 (0.001) 1460–1461 (0.008) 1466–1485 (0.009) 1500–1512 (0.0892)

hearths suggests a human response to environmental change within the last 2000 years. For whatever reason, Stud Creek was abandoned for a period measured in centuries. These results call into question the use of settlement system models that rely on the interpretation of the spatial distribution of a synchronic, surface archaeological record and studies of technology that suppose a uniform adaptation to a largely unchanging environment. Therefore, new approaches are needed to interpret surface records like that found in Stud Creek.

DISTRIBUTIVE APPROACHES

The alternative to a settlement system approach is to adopt distributional rather than partitive methods as suggested by Wandsnider (1996; Wandsnider and Camilli 1996). There are two key aspects to such an approach. First, it is necessary to replace the flawed notion of a settlement system, with its requirement that sites were in effect used simultaneously (i.e., were part of a single settlement system), reflecting locations used by people in response to an unchanging environment, with one where small individual blocks of landscape, for which a chronology can be established, are characterized by their depositional history: the frequency with which they were visited and used, and whether these visits were planned or unplanned, regular or erratic. Second, artifact analysis needs to concentrate, not on determining the synchronic function of sites in a stable settlement system, but on variables that reflect the formation history of the archaeological record. The individual life histories of artifacts are important, particularly how and when they were disposed of, rather than a search for synchronically related functional toolkits.

The implications of adopting this perspective at Stud Creek are seen first in the definition of the study area and the definition of assemblages. Following Wandsnider (who in turn builds on the work of Isaac 1981), we are not concerned with defining "sites" as the spatial reflection of a limited range of behaviors. Rather, we are interested in distinguishing the "hills and valleys" in the density of artifacts across a surface for which we have established an absolute chronology. At Stud Creek this means restricting our analysis to that part of the Stud Creek catchment where our geomorphic work indicates that the surface artifact scatters are no older than 2000 years B.P. and subject to the same geomorphological history. It also means analyzing three assemblages; two representing dense concentrations of artifacts (the "hills"—Stud 1 and 2 as discussed below) and a further sample spanning the density "valley" between these regions that we have called Stud Systematic (Fig. 3).

Second, we need a method for studying the artifacts based on their depositional history. To develop this we turned to the literature on artifact use-life, mobility, and raw material use. Binford (1977) demonstrated that the artifacts deposited at a location do not necessarily reflect the activities that took place there, since in some instances, artifacts were removed (i.e., curated or transported) after use. Several authors have used this observation to explain artifact assemblage composition as a function of mobility (e.g., Parry and Kelly 1987), however, Bamforth and Becker (2000) note that one of the factors complicating a general assessment of mobility is the degree to which mobile people reuse the same location over time.

Bamforth and Becker suggest that locations where resources are patchy will have different assemblages than those where resources are more evenly distributed. This is because there is a greater probability that long-life artifacts will be concentrated at places that are occupied more often. In regions where resources are more evenly spread, no one location will attract people more often than any other, so long use-life artifacts will be more widely and evenly distributed. Some artifacts were used for a variety of purposes, in a variety of places, before discard. Where an artifact is discarded is a function of its last use, however, where this last use occurred is a function of time. More of these long use-life artifacts will be abandoned in places occupied for greater lengths of time, simply because there is a greater probability that at such sites the period of occupation will exceed the remaining use-life of the artifact (Shott 1997).

In Australia, functional correlates of specific artifact forms are hard to determine (e.g., Hayden 1977; Kamminga 1978), largely because stone artifacts were manufactured to produce a wide range of other tool forms from different materials (e.g., wood). Most assemblages therefore represent aggregates of events where the functions cannot be specified. On the other hand, the fact that long use-life artifacts were abandoned (or not) at a particular location does give an indication of the duration over which activities were conducted.

Estimates of occupation duration may also be made by considering mobility, itself frequently determined by studies involving raw material access. Some materials maintain an edge for longer than others, are easier to resharpen, and can be worked more readily. For these reasons, such materials are desirable, but they are sometimes uncommon within a landscape. Since raw material procurement may be embedded in other activities (Binford 1979), access to high-ranking raw materials can be understood as a function of group mobility (Elston 1990). Highly mobile hunter-gatherers will have a greater opportunity to visit dispersed high-quality raw material sources and will tend to carry a small range of artifacts with them as part of their "personal gear" (Kuhn 1995 : 149). Assemblages produced by these individuals will therefore contain high proportions of nonlocal materials, as well as the remains of long use-life tools, or evidence of their reworking. In contrast, local materials will often dominate assemblages produced by individuals or groups with low mobility since there is less opportunity for embedded procurement. Such assemblages may be large, partly because less mobile groups will spend longer at one place, but also because larger volumes of waste will be produced when working materials of a lesser quality.

Where good quality raw material is more abundant, these distinctions may be less clear-cut. Material sources that are located within a few kilometers of a settlement may be visited directly or accessed through embedded procurement with only limited expenditure of additional effort compared to that needed to access local material. The degree to which one material will be preferred over another will depend on the relationship between the uses to which the material is to be put and the relative ease with which it may be worked, admittedly both difficult attributes to quantify. However, direct quantification of these variables may not be necessary to answer some research questions. Even a small difference in the effort required to access different sources of raw material may be reflected in assemblage composition and therefore be of use in assessing occupation duration.

Given the evidence for multiple occupations at Stud Creek, it would be interesting to determine whether assemblage analysis may be used to differentiate a smaller number of occupations by large number of people, versus a larger number of occupations by a smaller number of people. In other words, how do the lithic assemblages represent the distribution of person-days of activity? At one extreme of raw material access, one could imagine that increased occupation duration (and therefore less day-to-day access to nonlocal materials) will show higher proportions of local vs. nonlocal raw materials and increased numbers of long use-life tools, or their reworking products, relative to other tool forms. Increasing the number of people responsible for assemblage formation will obviously increase the size of assemblages relative to those produced by smaller groups, but not necessarily the relative proportions of artifact types or raw material proportions. This will depend on the degree of group mobility reflecting the ease with which non-local sources of quality material can be accessed and therefore the duration over which one location is occupied. Where raw material sources are not that distant, it obviously becomes easier to visit the nearby source to acquire better quality material, as it is required. Relationships between the intensity with which material is worked and distance to source are likely to be less evident, although they may not disappear completely. As Doleman et al. (2001) demonstrate, even over distances of a few hundred meters at Stud Creek, as one approaches sources of raw material there are indications of a distance decay relationship at least in artifact size. Over such small distances, relationships like this tell us little about lithic economy at the landscape scale, but they may be of use for investigating relative occupation duration at locations with similar access to raw material sources.

Tool manufacture is also sometimes used to measure occupation duration. Dibble and Rolland (1992), for instance, rank the intensity of site occupation based on flakes retouched into tools. The most intense, long-term occupations result in high proportions of tools relative to flakes and these tools are frequently resharpened. Conversely, assemblages representing occupation by more mobile groups over shorter durations will show lower proportions of tools and high proportions of unretouched flakes. A large proportion of the flake assemblage converted into repeatedly used tools implies a long duration of occupation. This works well where flake production is directed at producing blanks for retouch into tools, but is less suitable in many parts of Australia where retouched items form only a small proportion of many assemblages and studies show that unretouched flakes were used to complete a variety of tasks (e.g., Fullagar 1986; Fullagar and David 1997). As will be discussed below, some tool forms in the Stud Creek assemblages show evidence of heavy reworking, and these were probably produced from custom-made blanks. The majority of tools, however, shows only light retouch, and are manufactured on blanks only distinguishable by their size. Thus, it is not at all clear that flake blanks were manufactured for the primary production of tools at Stud Creek and more attention needs to be given to measures of the intensity of core reduction when attempting to assess occupation duration.

In sum, artifact use-life, mobility, and raw material access, interpreted from the perspective of artifact discard, may be used to inform on occupation duration. At Stud Creek, these factors are investigated in an environment of local raw material abundance. Duration as evidenced from repeated occupation is the goal here since is not possible to identify the artifacts resulting from single occupations. Nor can we discuss the nature of activities that went on at any one time. Raw material access and reduction together with the use-life of tools provide a series of methods that allow us to investigate occupation duration. All these relate to mobility but at least in the Stud Creek case, the distances covered to obtain stone were probably quite short. Thus, mobility as used here is not a reflection of a past settlement system or of the extent of landscape use. Stone was moved over short distances, but even this required some effort. Thus, determining the degree to which people accessed raw materials immediately at their feet vs. material in their immediate environment provides us with clues about how the "hills and valleys" reflect differing relative frequency and duration of occupation.

SURVEY AND ARTIFACT RECORDING

Three different approaches to assemblage creation were used at Stud Creek. In the first, aimed at relating artifact density and variability to land surface type at Stud 1 (Fig. 3), the characteristics of every artifact larger than 20 mm in maximum dimension were recorded, together with their location in three-dimensional space to the nearest centimeter measured with an electronic total station. The 20-mm-size cut-off for recording followed experimental work by Schick (1987:96) on

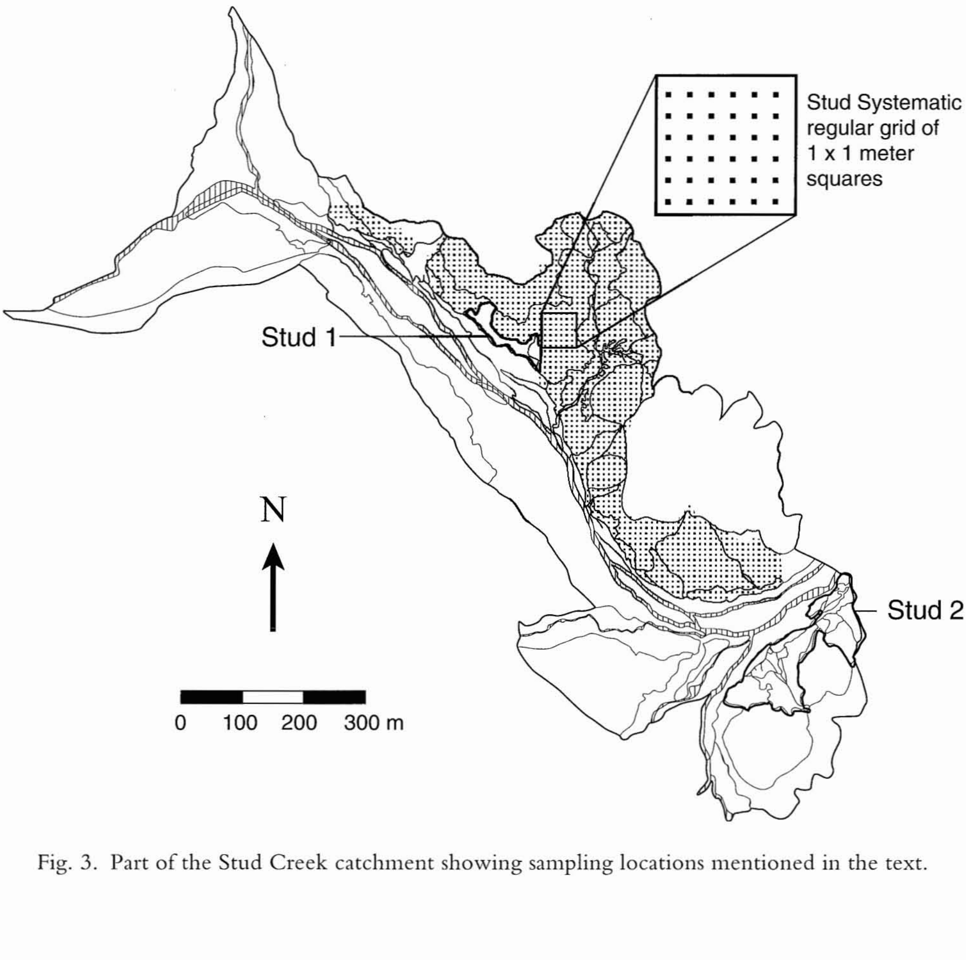


Fig. 3. Part of the Stud Creek catchment showing sampling locations mentioned in the text.

slope movement of artifacts and our own experience in the region (Fanning and Holdaway 2001*a*; Holdaway et al. 1998). Once the raw data were converted to a point coverage in the GIS, the relationships between a variety of artifact characteristics and land surface type could then be analyzed. Three-dimensional positioning allowed an assessment of artifact movement due to topographic factors such as slope (Fanning and Holdaway 2001*a*) and artifact visibility (Fanning and Holdaway 2004) to be made.

In the second approach, within-unit artifact variability was examined at Stud 2 (Fig. 3) by systematic, close-spacing survey of all of the artifacts within one land surface type (eroding valley margin or EVM) measured at the mesoscale. Having determined the likely range of artifact types and densities from this intensive piece proveniencing, systematic sampling techniques were applied in the third approach to a much larger area between Stud 1 and Stud 2, referred to here as Stud Systematic (Fig. 3). A grid of 1-by-1-m squares oriented north-south and east-west was laid out, and all the artifacts in every fifth square were recorded. This resulted in a 6 percent sample of a total area in excess of 120,000 m^2 being recorded. A 6 percent sampling fraction was selected based on the standard error for the number of tula adzes (Fig. 4) from Stud 1, where all visible artifacts over 20 mm in length were analyzed. The tula was selected for this calculation because it was a relatively rare, yet distinctive tool type. The 6 percent sample permitted estimates of the true number of tulas at Stud 1 plus or minus 50 percent. While this error range may seem high, a 6 percent sample gives estimates of rare types, like tulas, that are of the same order of magnitude as the true number. Estimates of the true number of more common forms are therefore likely to be much more accurate. A systematic, rather than random, sample was applied since the interest was in discovering regions of artifact concentration. Following Wandsnider (1998), the spacing of 1-by-1-m squares permits the identification of artifact clusters separated by at least 12 m (i.e., more than 2.5 times the spacing between the squares).

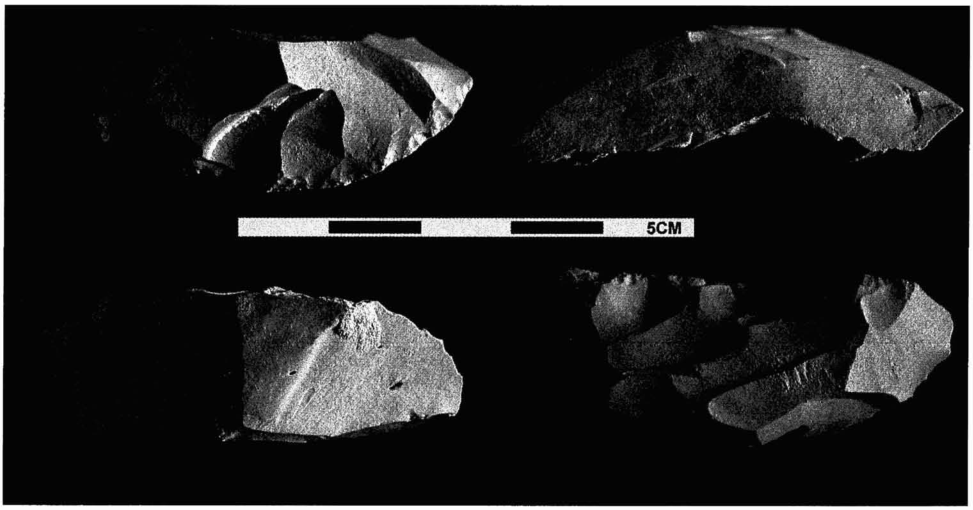


Fig. 4. Tula adze.

Artifacts were recorded individually in the field and then replaced where they were found. A series of technological and typological variables were described for each piece. These included the nature of the evidence for flaking (flake, tool, or core), the raw material type (silcrete, quartz, or quartzite, with finer divisions based on the organization and density of quartz clasts visible in the silcrete following Doelman et al. [2001]), the presence of cortex, the overall shape of the flake or core, the form of the tool and the number of retouched edges, and measurements of flake, tool, and core size. Inter-observer variability was assessed using a quality assurance program, the details of which are available elsewhere (Gnaden and Holdaway 2000).

ASSEMBLAGE ANALYSIS METHODS

The artifacts from each of the three locations at Stud Creek are treated here as separate assemblages. Stud 1 and Stud 2 are at opposite ends of the Stud Creek Valley, approximately 800 m apart (Fig. 3). They represent two of the densest surface deposits in the valley. The Stud Systematic sample extends between these two locations and samples areas with a range of densities. The databases created for each of these assemblages were checked for illegitimate errors (Gnaden and Holdaway 2000) before analysis began; artifacts with a maximum dimension less than 20 mm were removed, as well as those with clear transcription errors and null records (those where a location was recorded for a rock that turned out to be nonartifactual). Not all variables were recorded on all artifacts. Where an attribute or measurement could not be recorded, because the relevant landmark could not be identified, a null value was entered.

Three sets of stone artifact analyses are presented below as a means of assessing place use history at Stud Creek. In the first, the proportion of raw materials from different sources is used to provide an indication of the way that local vs. imported material was deposited. Second, a series of technological measures are used to assess the composition of the three assemblages in ways that reflect the relationship between mobility, occupation intensity, raw material choice, and discard. The flake to core ratio and related measures indicate the amount of core reduction and/or the removal of cores to new locations (Dibble et al. 1995). Tools are analyzed to determine the degree to which they have been resharpened. Third, assemblage composition is considered to determine the nature of differential discard across space.

RESULTS

Raw Materials and Assemblage Composition

Cretaceous Age deposits of silcrete are abundant in the Stud Creek region. They occur in two forms: outcrops and gibber plains. Outcrops with a massive appearance were frequently quarried in the past. Gibber pavements are extensive in the region covering the ranges and surrounding plains. Silcrete outcrops associated with substantial quarry debris occur within a few hundred meters of Stud 2 (Doelman et al. 2001). While it cannot be demonstrated from where individual artifacts derive, given the ubiquity of raw material sources in the region, it is reasonable to assume that the gibber pavements and the local outcrops are the source of material for the vast majority of the artifacts found in the Stud Creek Valley.

Doelman et al. identify three categories of silcrete based on hand specimen and thin section defined on the nature of the Cretaceous sediments before silicification; mudstone formed microcrystalline silcrete, muddy, fine sandstone formed fine-grained silcrete, while muddy medium sandstone formed medium-grained silcrete. The silcretes are differentiated in hand specimen on the basis of the proportion of microcrystalline quartz matrix and the size of the quartz clasts. The microcrystalline quartz matrix predominates in microcrystalline silcrete with scattered angular quartz clasts that range up to coarse sand-sized grains. Fine-grained silcrete is dominated by fine sand-sized quartz clasts with much less matrix than in the microcrystalline form. The quartz clasts are angular and poorly sorted, ranging up to very coarse sand in size. Medium-grained silcrete has well-sorted, subangular to subrounded quartz clasts that are mostly medium sand in size in a microcrystalline quartz matrix.

Material for artifacts manufactured from microcrystalline silcrete was generally obtained from quarries in the areas surrounding the upper Stud Creek catchment, while the majority of the gibber cobbles are formed from medium-grained silcrete. Fine-grained material is found in both forms. For this study, microcrystalline silcrete is treated separately, given its different flaking properties and probable quarry origin, but the medium- and fine-grained silcretes are not distinguished. Much of the medium-grained silcrete and some of the fine-grained silcrete probably originated as gibber cobbles, although some, no doubt, originated at the quarries. This uncertainty introduces a bias into the analyses presented below. However, this bias works against the conclusions that are drawn from the analyses. Any fine/medium-grained silcrete is treated here as originating from gibber even if it in fact originated from the quarries. This serves to make the assemblage manufactured from locally available material more similar to the assemblage manufactured from quarry material. Thus, any conclusions for a significant difference between locally available silcrete vs. that brought from the quarries is liable to be even stronger than that reported below.

Figure 5 presents artifact proportions by raw material from each of the three locations calculated in three different ways: as a proportion of the total number of artifacts, as a proportion of the minimum number of flakes (MNF, Holdaway and Stern 2004; Shott 2000), and as a proportion of the total length of artifacts. This helps to overcome the problem of measuring raw material proportions when artifacts have markedly different sizes or when one material has been subjected to a high degree of fragmentation relative to another. Total length (i.e., the sum of the maximum dimension of all artifacts) is used in place of weight since first, weight could not be easily measured in the field, and second, length and weight are closely correlated. For the Stud Creek assemblages, all three methods of calculating proportion produce similar results, indicating that artifacts manufactured from the different materials are broadly similar in size and were subjected to the same degree of fragmentation.

However, there are significant differences among the assemblages. The proportion of clast silcrete declines markedly from the Stud Systematic assemblage to

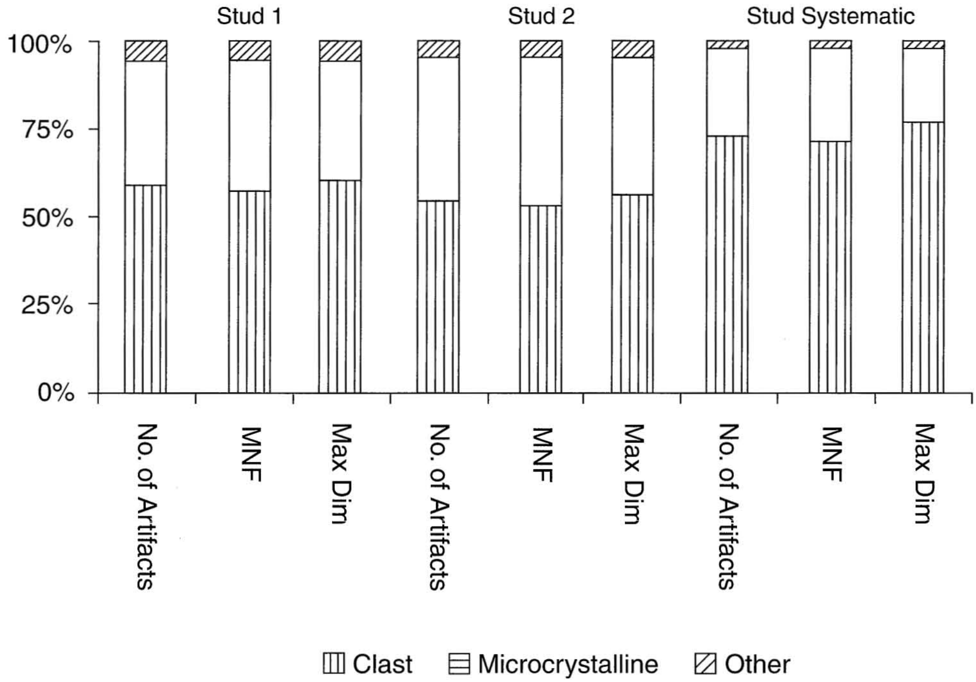


Fig. 5. Artifact proportions by raw material for each of the three sampling locations. In each case, proportion is calculated in three ways: number of artifacts refers to a count of all modified pieces, minimum number of flakes gives proportion based on a count of artifacts that retain a platform, and maximum dimension calculates proportion by summing the maximum clast dimension for all artifacts. Other raw materials combine artifacts manufactured from quartz, quartzite, and petrified wood.

the Stud 1 and Stud 2 assemblages, while the proportion of microcrystalline silcrete increases. Stud 2 has slightly more microcrystalline and less clast silcrete when compared to Stud 1. There are much smaller proportions of quartz and quartzite artifacts present in all three of the assemblages, with the lowest proportions of these materials in the Stud Systematic assemblage.

The density of artifacts also varies between each of the three locations. By far the densest concentration of artifacts is found at Stud 2, where there are 7.25 artifacts per square meter. This is almost six times the density found at Stud 1 (1.22 per m^2), while this location is 1.1 times as dense as Stud Systematic (1.11 per m^2). Some of this density difference is due to differential visibility (as noted above, Stud 2 was selected because it comprised an extensive area of lagged EVM surface) (Fanning and Holdaway 2004). However, the high density at Stud 2 also correlates with a number of technological differences in assemblage composition, demonstrating that visibility alone is not responsible for the density difference.

Technology and Assemblage Composition

Cortex — To determine whether the flakes, cores, and tools found at the three Stud Creek locations were knapped in place, or brought readymade from other

TABLE 2. LENGTH (MM) AND FREQUENCY OF COMPLETE FLAKES IN THE STUD CREEK ASSEMBLAGES, BY RAW MATERIAL AND CORTEX PROPORTION

ASSEMBLAGE	MATERIAL	STATISTIC	NO CORTEX	1–49%	50–100%
Stud 1	Clast	Mean	28.8	33.2	35.8
		Std. dev.	10.3	11.6	12.8
		Number	3811	2144	950
	Microcrystalline	Mean	26.1	29.4	34.7
		Std. dev.	9.4	10.6	12.9
		Number	2839	945	257
Stud 2	Clast	Mean	27.7	31.9	34.8
		Std. dev.	10.2	11.6	13.6
		Number	3594	1670	601
	Microcrystalline	Mean	25.2	29.8	32.3
		Std. dev.	9.1	11	12.1
		Number	3384	863	213
Stud Systematic	Clast	Mean	26.8	33.1	35.5
		Std. dev.	10.4	11.7	13.1
		Number	1431	681	348
	Microcrystalline	Mean	23.3	27.4	28
		Std. dev.	8.7	9.2	9.8
		Number	613	142	48

places, requires that evidence for reduction be found. Since stone working is a reductive process, flakes will often reduce in size as cores are flaked. Flakes removed at the start of a reduction process will also often have greater proportions of cortex on their dorsal surfaces than those removed later. Thus, a progressive diminution in flake size with decreasing proportions of cortex (or no cortex) supports an inference of in situ knapping. Exceptions to this pattern are known, particularly when core reduction is oriented at the production of flakes of a particular size or shape (e.g., Close 1999), but there is little evidence that such strategies were employed at Stud Creek. Table 2 provides the mean length for complete flakes per proportion of cortex obtained from each of the three locations (flake width, thickness, as well as platform width and thickness were also measured but the results, which were similar to those for length, are not tabulated to conserve space). The results of a number of statistical tests (analysis of variance [ANOVA] and t-tests) are summarized in Tables 3 to 5. The largest flakes made from both types of raw material at all three locations have the highest proportions of cortex. As cortex proportion reduces and is finally absent, there are significant reductions (Table 3) in complete flake length. For instance, for clast flakes from Stud 1, the mean lengths in Table 2 (read from right to left across the top row) show a reduction from 35.8 mm with 50–100 percent cortex, to 33.2 mm with 1–49 percent cortex and 28.8 mm with no cortex. This is clear evidence for in situ reduction of material from the locally available gibber cobbles and material brought to Stud Creek from the nearby quarries as cores.

Flake Size — Flake size can also be used to measure the intensity of flake reduction among the three sampling locations, because more reduction of cores will lead to smaller flakes. Comparisons of flakes manufactured from the same type

TABLE 3. RESULTS OF ANALYSIS OF VARIANCE (ANOVA) COMPARISONS BETWEEN THE LENGTH OF COMPLETE FLAKES AMONG THE THREE CORTEX CATEGORIES FOR EACH OF THE RAW MATERIAL GROUPS

ASSEMBLAGE	CLAST	MICROCRYSTALLINE
Stud 1	$F = 207.8$ $df = 2, 6902$ $p = <.001$	$F = 113.9$ $df = 2, 4038$ $p = <.001$
Stud 2	$F = 153.5$ $df = 2, 5862$ $p = <.001$	$F = 119.6$ $df = 2, 4457$ $p = <.001$
Stud Systematic	$F = 125.6$ $df = 2, 2457$ $p = <.001$	$F = 16.9$ $df = 2, 800$ $p = <.001$

of raw material and having similar proportions of cortex from each of the three locations demonstrate small, but significant, differences in length in each case (except clast silcrete with 50–100 percent cortex, Table 4). Means and standard deviations upon which these tests are based are given in Table 2. For example, for clast silcrete with no cortex the ANOVA result reported in the first cell of Table 4 reports on a comparison of flakes with mean lengths of 28.8 Stud 1, 27.7 Stud 2, and 26.8 for Stud Systematic read from cells in alternating rows in column one of Table 2. Unlike the change in mean length with cortex proportion, the direction of change for this test varies between the two raw material groups. For clast silcrete, Stud 2 has the shortest flakes (except for clast flakes without cortex where the mean length of Stud 2 and Stud Systematic flakes are very close). For microcrystalline silcrete, flakes from Stud Systematic are smaller than flakes from both Stud 1 and Stud 2. At face value, this would suggest that greater reduction of microcrystalline material occurred at Stud Systematic. However, flake size is not the only measure of stone artifact reduction.

Flake to Core Ratio — The ratio of flakes to cores provides another measure of reduction intensity. As the intensity of reduction increases, more flakes will be produced from each core so this ratio will rise. The ratio will also rise if cores are

TABLE 4. RESULTS OF ANALYSIS OF VARIANCE (ANOVA) COMPARISONS BETWEEN THE LENGTH OF COMPLETE FLAKES FROM EACH ASSEMBLAGE LOCATION

CORTEX	CLAST	MICROCRYSTALLINE
No cortex	$F = 21.2$ $df = 2, 8833$ $p = <.001$	$F = 24.5$ $df = 2, 6833$ $p = <.001$
1–49%	$F = 6.9$ $df = 2, 4492$ $p = .001$	$F = 3.1$ $df = 2, 1947$ $p = .046$
50–100%	$F = 1.1$ $df = 2, 1896$ $p = .364$	$F = 6.9$ $df = 2, 515$ $p = .001$

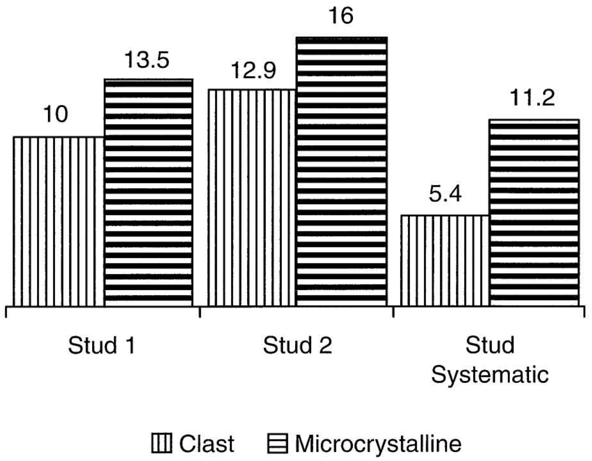


Fig. 6. Flake to core ratio for each of the three sampling locations.

removed at the end of a flaking episode for use elsewhere or fall if the opposite occurs and flakes are removed. However at Stud Creek it seems unlikely that flakes were removed often, since flake size discussed above is consistent with in situ reduction. Plotting this ratio for the three locations provides a quite different result to the analysis of flake dimensions (Fig. 6). The Stud Systematic assemblage has the lowest MNF to core ratio, while Stud 2 has the highest. This suggests that greatest reduction occurred at Stud 2, not at Stud Systematic or cores were removed more often from the Stud 2 location.

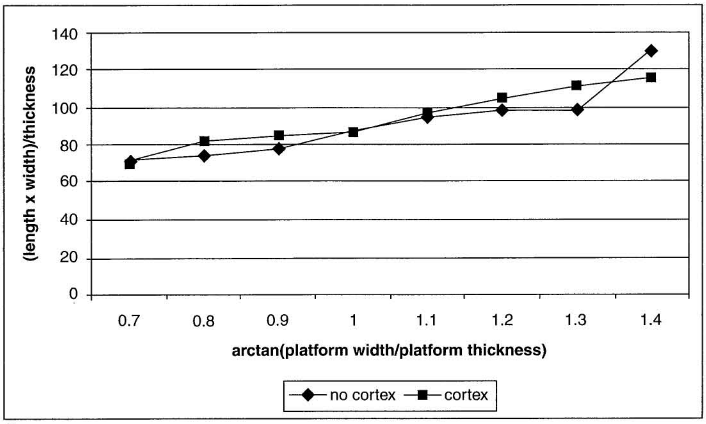
An explanation for these apparently conflicting results may relate to the size of the cobbles selected for knapping that differed among the three locations. Smaller cobbles will inevitably lead to smaller flakes, and there is some evidence that this is the case for the Stud Systematic assemblage. First, the average length of microcrystalline complete flakes with high proportions of cortex (50–100 percent) is smaller at Stud Systematic than at either Stud 1 or 2 (for clast silcrete there is no significant difference among the three assemblages) (Table 2, statistical tests summarized in Table 4). This is a surprising result if intensity of reduction alone was responsible for size differences, since flakes with high proportions of cortex were removed at the start of the reduction process and therefore should show little reduction in size. However, if the cobbles used in the creation of the Stud Systematic assemblage were indeed smaller than those used at Stud 1 and Stud 2, then relatively smaller sized, highly cortical flakes would be expected. Second, there is a significant, but weak, tendency for increased proportions of flakes with 50–100 percent cortex in the Stud Systematic assemblage compared to the proportions of flakes without cortex at Stud 1 and 2 (microcrystalline $\chi^2 = 14.4$, $df = 2$, $p = .001$, $phi = .04$; clast $\chi^2 = 53.6$, $df = 2$, $p < .001$, $phi = .07$). In these tests, the number of flakes in each of the three assemblages and each of the three cortex proportion classes given in Table 2 are compared and chi-square statistics calculated. A separate test is run for each of the two raw materials. Increased proportions of flakes with high proportions of cortex are to be expected if cobbles were indeed smaller at Stud Systematic, due to changes in the surface area to volume ratio (i.e., small cobbles have a higher ratio).

Flake Shape — Core reduction may lead to changes in the shape of the flakes produced (Dibble 1997). Experiments suggest that for a given exterior platform angle, increasing the thickness of the platform will produce a heavier flake. However, increasing the platform width relative to the platform thickness will change the distribution of this weight, producing flakes that have larger surface areas (length × width) relative to their thickness. Roth and Dibble (1998) note that this may be desirable if flakes rather than cores are to be transported from a quarry, since a larger surface area corresponds to an increased length of cutting edge relative to weight. However, there is little evidence to suggest that this was a frequent occurrence at Stud Creek.

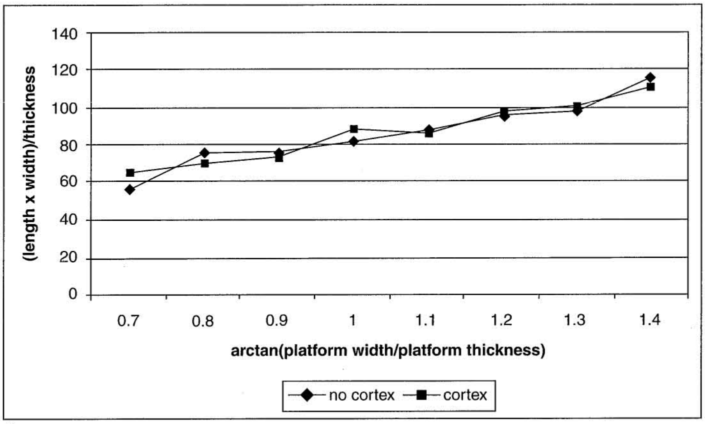
Figure 7 presents plots for clast and microcrystalline silcrete for each of the three assemblages. In all cases, flakes with cortex (i.e., those with 1–49 percent or 50–100 percent cortex) tend to have higher surface area to thickness ratios than flakes without cortex (i.e., those with no cortex). That is, the lines in each of the graphs reported in Figure 7 for cortical flakes plot above those without cortex. This supports the interpretation that cobble reduction occurred in situ since flakes with greater surface areas are more likely to be produced at the start of the reduction process than at its end. However, the clast flake assemblage has uniformly larger surface area to thickness values than the microcrystalline flakes.

If the source of microcrystalline silcrete flakes is cores transported from quarries, differences in relative flake shape may relate to intensity of core reduction. As stated above (Fig. 6), Stud 2 has the highest flake to core ratio, followed by Stud 1 and Stud Systematic. In each case, this ratio is higher for microcrystalline silcrete than it is for the clast material. This suggests that either microcrystalline silcrete cores were reduced further (hence producing more flakes) than clast cores or that microcrystalline cores were removed more often than clast silcrete cores. Support for the former interpretation comes from comparisons of the mean size of complete flakes grouped by location, cortex proportion and raw material type. For length (Table 2), the results of t-tests (Table 5) show a significant difference between the two material groups in each of the three locations, and for the three cortex categories (except flakes with 50–100 percent cortex at Stud 1). As an example, the test statistic for Stud 1, no cortex, reported in Table 5 compares clast silcrete complete flake mean length of 28.2 mm with microcrystalline complete flake mean length of 26.1 mm. In each test, clast silcrete flakes are larger than their microcrystalline flake equivalents. These differences may partially reflect differences in raw material size; clast flakes with 50–100 percent cortex are larger than microcrystalline cortical flakes in every instance, although these differences are not always significant. But the MNF to core ratios suggest that reduction intensity was also significant.

Other Measures of Reduction — The above interpretation is supported by a number of other measures of reduction intensity. For instance, increased reduction of cores will produce relatively larger numbers of noncortical to cortical flakes (Dibble et al. 1995; Roth and Dibble 1998). Figure 8 presents the noncortical to cortical flake ratio for the three locations and each raw material category. The clear difference in reduction intensity shown by the complete flake to core ratio is supported; the Stud 2 assemblage demonstrates higher intensity of core reduction than either Stud 1 or Stud Systematic.



A.



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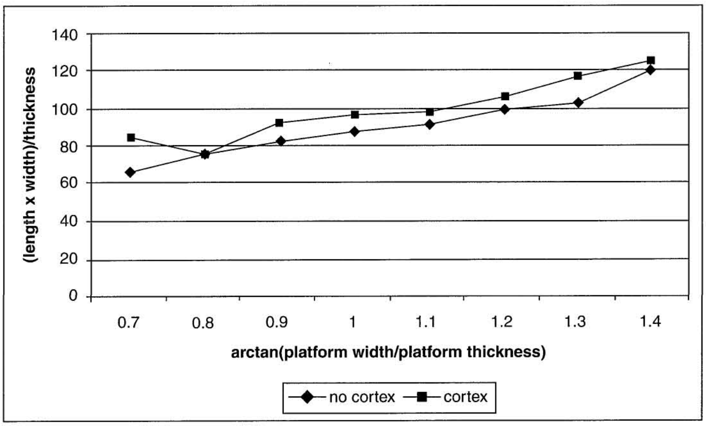
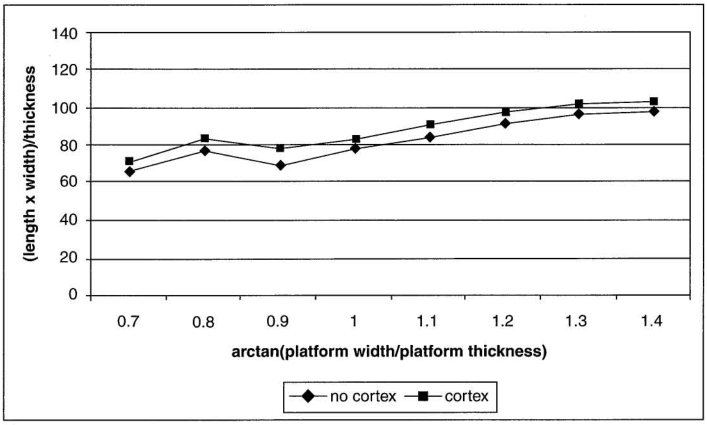


C.

Fig. 7. Plots of the relative shape of complete flakes from each of the sample locations and each raw material category. A separate graph traces the plot for cortical and noncortical flakes: a: Stud 1 clast cortical and noncortical shape plot, b: Stud 1 microcrystalline cortical and noncortical shape plot, c: Stud 2 clast cortical and noncortical shape plot, d: Stud 2 microcrystalline cortical and noncortical shape plot, e: Stud Systematic clast cortical and noncortical shape plot, f: Stud Systematic microcrystalline cortical and noncortical shape plot. Lines give the relative shape of flakes for each mean arctan platform width to thickness ratio value (read from the left-hand Y axis).



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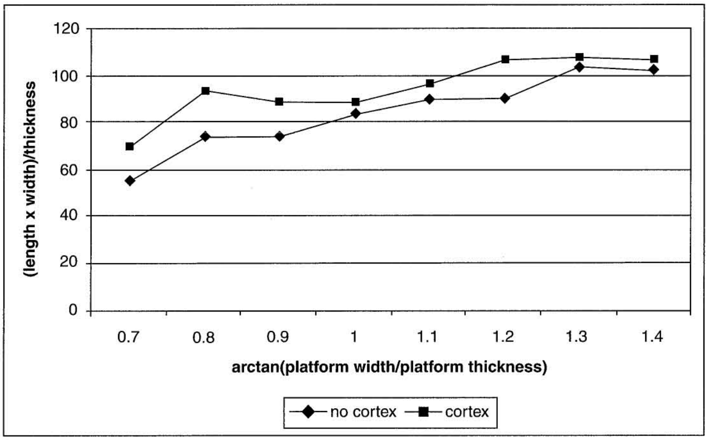

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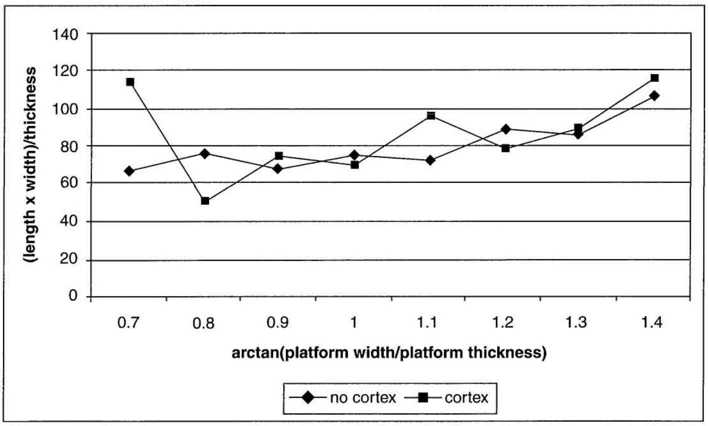

F.

Fig. 7 *(Continued)*

TABLE 5. RESULTS OF *t*-TEST COMPARISONS BETWEEN THE MEAN LENGTHS OF COMPLETE FLAKES FROM EACH RAW MATERIAL CATEGORY

ASSEMBLAGE	NO CORTEX	1–49%	50–100%
Stud 1	$t = 11.02$	$t = 8.88$	$t = 1.12$
	$df = 6375.46$	$df = 1957.88$	$df = 1205$
	$p = .001$	$p = .001$	$p = .263$
Stud 2	$t = 10.99$	$t = 4.31$	$t = 2.38$
	$df = 6952.53$	$df = 2531$	$df = 812$
	$p = .001$	$p = .001$	$p = .018$
Stud Systematic	$t = 7.95$	$t = 6.45$	$t = 3.79$
	$df = 1368.10$	$df = 247.49$	$df = 394$
	$p = .001$	$p = .001$	$p = .001$

Fragmentation — The process of core reduction may also lead to the production of large numbers of broken flakes and flake fragments (e.g., Dibble 1995), thus the ratio of complete to broken flakes (i.e., proximal, medial, and distal flake fragments together with flaked pieces) acts as a measure of core reduction intensity (although admittedly on its own this ratio may also reflect the degree of post-depositional fragmentation). Figure 9 presents these ratios for both silcrete classes from each of the three locations. Stud 2 has the lowest values for these ratios in both raw material classes, indicating that there are more broken flakes relative to complete flakes at this location and by inference, core reduction was more intensive here than elsewhere. The alternative interpretation, is that Stud 2 saw more post-depositional breakage that the other two locations.

Exterior Platform Angle — Flake exterior platform angles will often increase as core reduction continues (although this process will depend on the level of core rejuvenation undertaken). Although there is often a high level of random error in recording this attribute, there is little systematic error, so while it is not very precise, this attribute is an accurate measurement of flake shape (Gnaden and Holdaway 2000). Following Dibble (1997), flake shape can be measured by plotting exterior platform angle against flake length divided by platform thickness. Figure

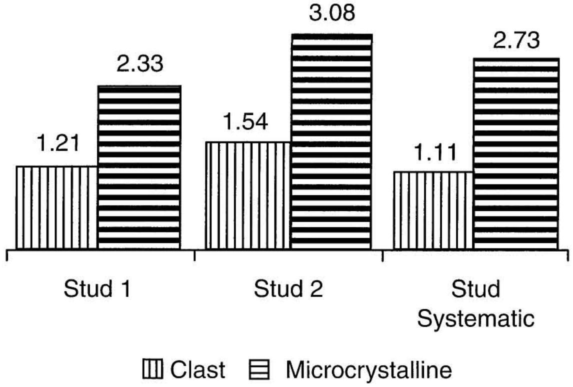

Fig. 8. Noncortical to cortical flake ratio for each of the sampling locations.

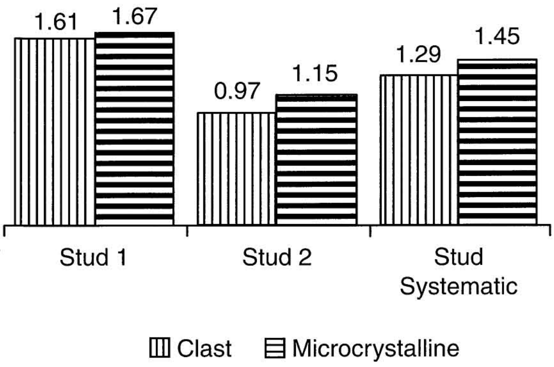

Fig. 9. Ratio of complete to broken flakes for each of the sampling locations.

10 presents the results for Stud 2 (exterior angle was not measured at Stud 1 or Stud Systematic). For a given exterior platform angle, microcrystalline silcrete flakes have a higher length to platform thickness ratio than clast flakes for angles greater than 60° (only a minority of flakes have edge angles lower than this value). In other words, as exterior angle increases, microcrystalline flakes become more blade-like, in the sense that they are longer relative to platform thickness, than clast flakes (Table 6).

Cores — A final set of analyses relevant to reduction intensity utilizes the cores rather than the flakes. Core volume should decrease as reduction proceeds, so assemblages that have been reduced the most should show relatively low core

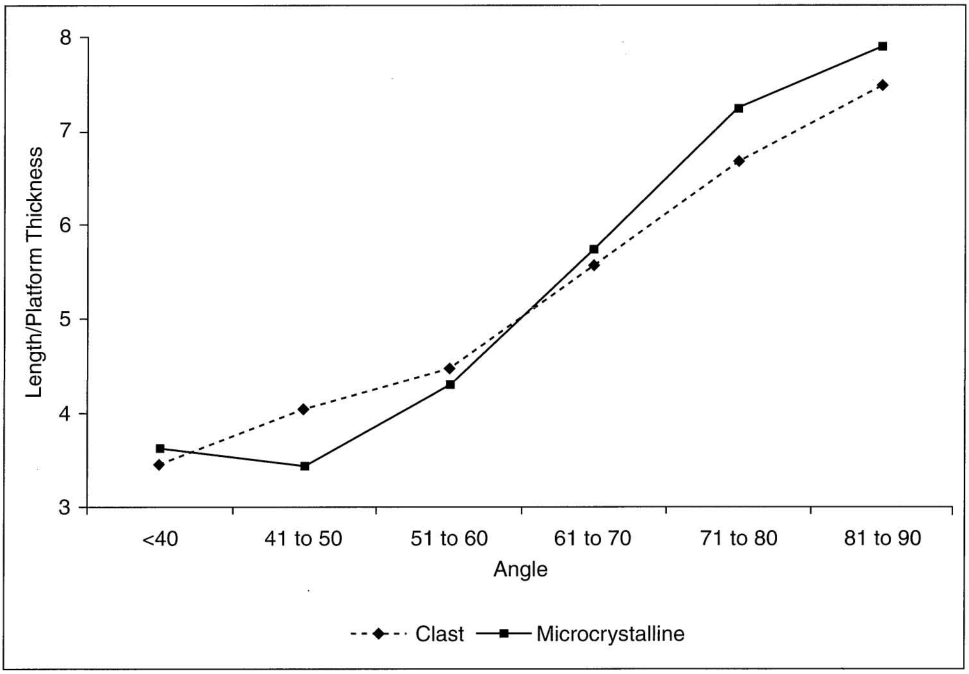

Fig. 10. Exterior platform angle against flake length divided by platform thickness for Stud 2.

TABLE 6. COMPLETE FLAKE FORM PROPORTIONS FOR EACH ASSEMBLAGE LOCATION BY RAW MATERIAL

	STUD 1		STUD 2		STUD SYSTEMATIC	
	CLAST	MICROCRYSTALLINE	CLAST	MICROCRYSTALLINE	CLAST	MICROCRYSTALLINE
Blade	8.4%	5.9%	3.4%	2.6%	2.9%	4.4%
Indeterminate	67.4%	70.9%	67.7%	66.6%	64.3%	64.1%
Expanded	20.1%	19.6%	26.6%	28.5%	30.8%	29.2%
Block	4.1%	3.6%	2.3%	2.3%	1.9%	2.3%

volumes (Roth and Dibble 1998). The different technologies employed leading to the production of different core shapes complicates this relationship. Of the core types recorded at Stud Creek, microblade cores have the smallest volume, while test cores have the largest. This is because test cores were defined as those exhibiting only one or two flake removals from a cortical cobble. Microblade cores, on the other hand, were deliberately shaped in order to manufacture small blades; hence they have a small volume. Comparisons between assemblages, therefore, need to be made with cores of the same type. Table 7 presents mean core volumes for the four core categories identified in each of the three locations, divided by raw material group. Microcrystalline cores have a smaller volume than clast cores in each case. Finally, noncortical core to cortical core ratios can be cal-

TABLE 7. CORE VOLUMES IN CUBIC MILLIMETERS

ASSEMBLAGE	MATERIAL	CORE TYPE	MEAN	STD. DEV.	NUMBER
Stud 1	Clast	Bifacial	81,626.8	115,039.2	313
		Microblade	28,147.3	18,262.5	24
		Test	108,924.1	102,711.3	145
		Unifacial	73,322.3	72,329.4	447
	Microcrystalline	Bifacial	45,563.3	47,452.4	191
		Microblade	21,989.3	18,190.8	27
		Test	107,526.4	124,419.7	25
		Unifacial	40,762.7	48,973.6	197
Stud 2	Clast	Bifacial	105,575.5	142,494.5	201
		Microblade	26,257.9	20,664.6	14
		Test	184,081.5	167,740.3	102
		Unifacial	95,992.3	95,353.9	318
	Microcrystalline	Bifacial	60,032.5	101,776.8	157
		Microblade	20,911.6	14,181.9	31
		Test	140,729.6	105,032.7	29
		Unifacial	71,452.7	134,597.9	190
Stud Systematic	Clast	Bifacial	121,535.5	173,674.8	144
		Microblade	39,063.3	35,305.4	9
		Test	172,272.2	188,474.7	221
		Unifacial	135,356.3	198,744.8	272
	Microcrystalline	Bifacial	46,703.0	55,131.0	40
		Microblade	32,328.0	25,869.1	21
		Test	125,912.1	188,144.7	8
		Unifacial	53,784.9	72,794.4	48

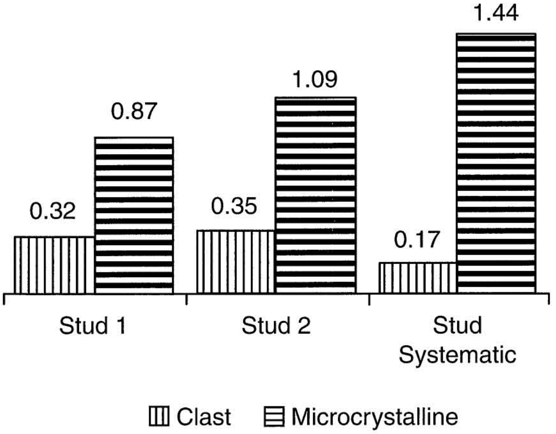

Fig. 11. Noncortical core to cortical core ratios for each of the sampling locations.

culated in the same way as the ratio for noncortical to cortical flakes discussed earlier (Fig. 11). The number of cores that lack cortex compared to the number of cores for which cortex was recorded in the 1–49 percent and 50–100 percent categories used for complete flakes. For clast silcrete artifacts, Stud Systematic has the lowest value for this ratio, indicating that there are many fewer noncortical compared to cortical cores in comparison to the other assemblages. This supports the conclusion that relatively smaller cobbles were worked at Stud Systematic. This trend is reversed for microcrystalline silcrete: the noncortical to cortical core ratio is relatively high for Stud Systematic, which may be explained by the high proportion of microcrystalline microblade cores (17.9 percent of the total) compared to 6 percent and 8 percent at Stud 1 and Stud 2, respectively.

Summary — There are clear differences in the intensity of reduction at the three Stud Creek locations based on measures of the size of flakes, the presence of cortex, and the relative proportions of flakes and cores. Microcrystalline silcrete was flaked more intensively than clast silcrete, and the assemblages at Stud 1 and at Stud 2 represent more intense core reduction than in the Stud Systematic assemblages. Accepting intensity of reduction as a measure of occupation duration and therefore mobility, different parts of Stud Creek were occupied in different ways, that is, had different place use histories during the course of the last 2000 years.

Tools

Tool Types — Tool type proportions by raw material and locations are presented in Table 8. Three tool categories, utilized flakes, scrapers, and notches, account for the majority of the tools in all three of the assemblages. There are significant differences in the proportions of these tools made from clast and microcrystalline silcrete at each of the three locations the most obvious of which is the near absence of adzes (tula and burren) manufactured from clast silcrete. For clast silcrete, the proportion of scrapers is the same for each assemblage (approximately 36 percent), but Stud 2 has proportionally more notched tools and fewer utilized flakes than Stud 1, while Stud Systematic has more utilized flakes and fewer notched

TABLE 8. FREQUENCY OF EACH TOOL TYPE MANUFACTURED FROM DIFFERENT MATERIALS WITH PROPORTION CALCULATED FOR EACH SAMPLING LOCATION (ACROSS ROWS)

ASSEMBLAGE	MATERIAL	UTILIZED FLAKE	SCRAPER	TULA AND BURREN	NOTCH	BACKED PIECE AND GEOMETRIC	OTHER TOOL TYPES
Stud 1	Clast	317	357	9	261	38	14
		31.8%	35.8%	0.9%	26.2%	3.8%	1.4%
	Microcrystalline	330	365	124	199	23	25
		31.0%	34.2%	11.6%	18.7%	2.2%	2.3%
Stud 2	Clast	151	183	5	141	26	3
		29.7%	36.0%	1.0%	27.7%	5.1%	0.6%
	Microcrystalline	284	292	119	144	28	7
		32.5%	33.4%	13.6%	16.5%	3.2%	0.8%
Stud Systematic	Clast	163	157	0	86	13	2
		38.7%	37.3%	0.0%	20.4%	3.1%	0.5%
	Microcrystalline	136	85	29	36	9	5
		45.3%	28.3%	9.7%	12.0%	3.0%	1.7%

tools than either of the other two assemblages. There are also significant differences in the proportion of each tool category manufactured from the two raw material groups among the three locations (Table 9). Thus, more utilized flakes are manufactured from microcrystalline silcrete at Stud 2 than is true at either of the other locations. There are also proportionally more scrapers and notches manufactured from this material at Stud 2 compared to the two other assemblages. The same trend is apparent for backed blades, but the differences are not significant. Some of each of the differences are due to the variations in the proportion of raw materials used for all classes of artifacts at the three locations, but tests between tool and flake frequencies indicate that raw materials were selected for the manufacture of tools in different proportions to their selection for the

TABLE 9. FREQUENCY OF UTILIZED FLAKES, SCRAPERS, AND NOTCHES WITH PROPORTION CALCULATED FOR EACH ARTIFACT TYPE MANUFACTURED FROM THE TWO RAW MATERIAL CLASSES

ASSEMBLAGE	MATERIAL	UTILIZED FLAKES	SCRAPERS	TULAS AND BURRENS	NOTCHES	BACKED PIECE AND GEOMETRICS	OTHER TOOL TYPES
Stud 1	Clast	317	357	9	261	38	14
		49.0%	49.4%	6.8%	56.7%	62.3%	35.9%
	Microcrystalline	330	365	124	199	23	25
		51.0%	50.6%	93.2%	43.3%	37.7%	64.1%
Stud 2	Clast	151	183	5	141	26	3
		34.7%	38.5%	4.0%	49.5%	48.1%	30.0%
	Microcrystalline	284	292	119	144	28	7
		65.3%	61.5%	96.0%	50.5%	51.9%	70.0%
Stud Systematic	Clast	163	157	0	86	13	2
		54.5%	64.9%	0.0%	70.5%	59.1%	28.6%
	Microcrystalline	136	85	29	36	9	5
		45.5%	35.1%	100.0%	29.5%	40.9%	71.4%

manufacture of flakes for all cases except notched tools from Stud Systematic, where the difference is not significant ($\chi^2 = .38$, $df = 1$, $p = .54$). One possibility is that tool proportions, particularly those for utilized flakes and notches, are biased by artifacts damaged in a way that makes them appear as though they were tools. While this is a possibility, we think that the way we defined notches (as complex notches with multiple flake removals rather than the single Clactonian form) and the very consistent pattern in relative tool proportion between raw materials for more and less retouched tool forms argues against this. If post-depositional disturbance was significantly affecting tool proportions through the formation of pseudo-tools, we might expect these forms to appear in greater proportions in artifacts manufactured from microcrystalline silcrete, since this material is more susceptible to damage. The results (Table 9) show that for Stud 1 and Stud Systematic, it is clast silcrete that has higher proportions of these tool forms than microcrystalline silcrete. At Stud 2, microcrystalline utilized flakes and notched tools do appear in higher proportions but this difference is matched by a change in the proportion of scrapers. Since scrapers are defined by the presence of multiple flake removals, it seems hard to explain the increased proportion of this tool form manufactured from microcrystalline silcrete as a product of post-depositional disturbance. At Stud 2, utilized flakes and notches show the same trend as scrapers, therefore we think that the pattern is unlikely to reflect the post-depositional production of artifact damage.

Tool Dimensions — Dimensions on all tool classes indicate that artifacts with retouch were manufactured on flakes that are, on the whole, larger compared to those without retouch (Tables 10, 11). This is true even when dimensions alone

TABLE 10. MEAN LENGTH (MM) OF COMPLETE TOOLS IN THE STUD CREEK ASSEMBLAGES, BY RAW MATERIALS AND TOOL TYPE

ASSEMBLAGE	MATERIAL	STATISTIC	COMPLETE FLAKE	NOTCHED	SCRAPER	UTILIZED FLAKE
Stud 1	Clast	Mean	31.1	39.9	39.3	34.3
		Std. dev.	11.4	13.9	11.5	11.3
		Number	6905	261	354	317
	Microcrystalline	Mean	27.4	33.9	34.1	30.2
		Std. dev.	10.2	11.7	11.7	10.3
		Number	4043	199	360	330
Stud 2	Clast	Mean	29.6	38.1	40.1	34.7
		Std. dev.	11.3	10.5	12.7	11.2
		Number	5866	140	183	150
	Microcrystalline	Mean	26.4	33.9	33.2	30.1
		Std. dev.	9.9	11.4	10.5	10.3
		Number	4461	144	265	283
Stud Systematic	Clast	Mean	29.8	39.3	37.6	32.8
		Std. dev.	11.7	12.5	11.7	11.5
		Number	2461	85	156	162
	Microcrystalline	Mean	24.3	31.9	31.7	27.6
		Std. dev.	9	8.5	10.1	9.3
		Number	804	36	84	136

TABLE 11. COMPARISON OF MEAN COMPLETE TOOL LENGTH WITH MEAN COMPLETE FLAKE LENGTH FOR EACH SAMPLE LOCATION AND RAW MATERIAL TYPE

ASSEMBLAGE	MATERIAL	NOTCHED	SCRAPER	UTILIZED
Stud 1	Clast	$t = 10.14$ $df = 273.39$ $p = .001$	$t = 13.20$ $df = 7257$ $p = .001$	$t = 4.92$ $df = 7220$ $p = .001$
	Microcrystalline	$t = 6.92$ $df = 213.12$ $p = .001$	$t = 10.41$ $df = 408.95$ $p = .001$	$t = 4.77$ $df = 4371$ $p = .001$
Stud 2	Clast	$t = 8.74$ $df = 6004$ $p = .001$	$t = 11.06$ $df = 191.14$ $p = .001$	$t = 5.43$ $df = 6014$ $p = .001$
	Microcrystalline	$t = 7.78$ $df = 150$ $p = .001$	$t = 10.13$ $df = 292.3$ $p = .001$	$t = 6.33$ $df = 4742$ $p = .001$
Stud Systematic	Clast	$t = 7.33$ $df = 2544$ $p = .001$	$t = 8.08$ $df = 2615$ $p = .001$	$t = 3.12$ $df = 2621$ $p = .002$
	Microcrystalline	$t = 4.96$ $df = 838$ $p = .001$	$t = 7.07$ $df = 886$ $p = .001$	$t = 3.87$ $df = 938$ $p = .001$

are considered, ignoring the reduction in original flake blank size that occurs during retouching. When estimates of original blank size are made before retouch commenced (based on the work of Dibble 1987), it is clear that some of the largest flakes available were selected for retouch.

Different tool categories have different values for the width to platform thickness ratio or the length to platform thickness ratio indicating variation in the proportion of the original blank removed through retouch. The different ratios are used for tools where retouch is present on the distal end of the tool (the length to platform thickness ratio) or on the lateral margins (the width to thickness ratio). The different values for these ratios reflect tool type definition: the retouch on utilized flakes is not as invasive as that on scrapers, hence the values for the ratios are higher. However, within each tool category, there is little to suggest differences in the intensity of retouch among the three assemblages (Table 12). Neither scrapers with retouch at the distal end nor those with retouch on the lateral margins have been retouched more invasively at Stud 2 when compared to either Stud 1 or Stud Systematic. Differences that do exist are in the relative frequency of tool types rather than the intensity of retouch.

Flake to Tool Ratio — The flake to tool ratio is also different for each of the three locations (Fig. 12). Stud 2 has the highest values for both raw materials while the lowest values, also for both materials, are found at Stud Systematic. Stud 2 evidently has many more flakes than tools in comparison to the other locations, a result that is discussed in relation to changes in the intensity of site use below.

Summary — The most striking difference in the tool types manufactured from different materials is the near absence of tulas (Fig. 4) manufactured from clast sil-

TABLE 12. RATIOS OF TOOL LENGTH TO PLATFORM THICKNESS AND TOOL WIDTH TO PLATFORM THICKNESS FOR EACH ASSEMBLAGE

ASSEMBLAGE	MATERIAL	STATISTIC	LENGTH/PLATFORM THICKNESS	WIDTH/PLATFORM THICKNESS
		Notches		
Stud 1	Clast	Mean	5.1	3.7
		Std. dev.	3.3	1.6
		Number	97	108
	Microcrystalline	Mean	5	4.1
		Std. dev.	3.4	3.1
		Number	100	62
Stud 2	Clast	Mean	5.2	3.5
		Std. dev.	4.1	1.9
		Number	61	61
	Microcrystalline	Mean	5.9	4
		Std. dev.	6.3	2.1
		Number	84	34
Stud Systematic	Clast	Mean	4.4	3.8
		Std. dev.	2.9	1.9
		Number	36	34
	Microcrystalline	Mean	6.1	3.9
		Std. dev.	5	1.4
		Number	21	9
		Utilized Flakes		
Stud 1	Clast	Mean	5.5	4.1
		Std. dev.	4	2.2
		Number	117	157
	Microcrystalline	Mean	5.3	4.7
		Std. dev.	4.2	3.1
		Number	147	133
Stud 2	Clast	Mean	5.8	5
		Std. dev.	4.9	5
		Number	76	51
	Microcrystalline	Mean	6.3	5.1
		Std. dev.	5.2	3.3
		Number	151	100
Stud Systematic	Clast	Mean	5.6	5.4
		Std. dev.	3.3	4.5
		Number	64	74
	Microcrystalline	Mean	5.7	5.4
		Std. dev.	3.1	3.4
		Number	61	53
		Scrapers		
Stud 1	Clast	Mean	6	4.5
		Std. dev.	3.9	2.7
		Number	192	88
	Microcrystalline	Mean	5.3	4.5
		Std. dev.	4	5
		Number	207	62

(Continued)

TABLE 12 *(Continued)*

ASSEMBLAGE	MATERIAL	STATISTIC	LENGTH/PLATFORM THICKNESS	WIDTH/PLATFORM THICKNESS
Stud 2	Clast	Mean	5.2	4.3
		Std. dev.	3.4	2.5
		Number	116	32
	Microcrystalline	Mean	5.8	4.3
		Std. dev.	4.5	3.7
		Number	170	49
Stud Systematic	Clast	Mean	5.1	5.1
		Std. dev.	3	3.3
		Number	98	28
	Microcrystalline	Mean	5.4	4.2
		Std. dev.	3.1	2.6
		Number	46	17

crete: these tools are made largely from microcrystalline material. All other major tool types are found in both materials. Differences exist in the relative proportions of tools between each of the assemblage locations, and there are significant differences in the proportions of tools of the same type manufactured from the two different categories of silcrete. Tools of all forms are large relative to flakes manufactured from the same materials. Among the three assemblages, there is little difference in the intensity of retouch although there is a clear distinction as measured by the flake to tool ratio.

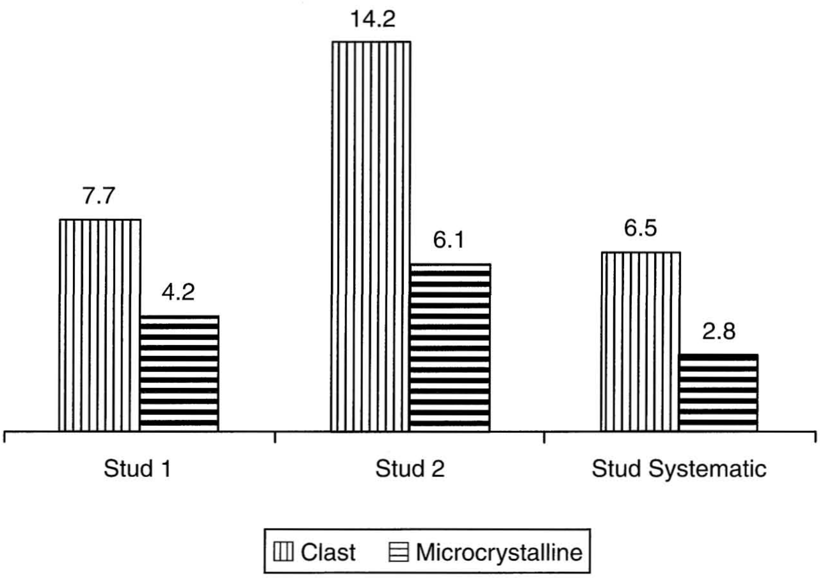

Fig. 12. Flake to tool ratios for each of the sampling locations.

DISCUSSION

Silcrete forms the material of choice for the Indigenous Australians who occupied Stud Creek, an observation that will surprise few, given the ubiquity of the material in outcrops and gibber plains. Despite the proximity of the quarries and gibber cobbles, there is clear evidence for choice in the way the material was worked and in the movement of stone to particular locations on the landscape. Size differences for microcrystalline silcrete complete flakes suggest that larger cores were worked and the debris deposited more often at Stud 2 than at surrounding locations. The flake to core ratio, fragmentation ratio, and the relative sizes of flakes and cores at Stud 2 indicate that this location also saw more intensive reduction of microcrystalline cores than either Stud 1 or Stud Systematic. Microcrystalline silcrete was reduced further than clast silcrete at all locations, and plotting exterior platform angle against the ratio of flake surface area to platform area suggests microcrystalline flakes were more blade-like compared to clast flakes, although morphologically defined blades are rare in all assemblages.

Tools show similar differences in proportion between the sampling locations. Proportionally more scrapers, notched tools, and utilized flakes are manufactured from microcrystalline silcrete rather than clast silcrete at Stud 2 when compared to the other sampling locations.

Put simply, there is good evidence that Stud 2 saw a greater intensity of occupation than the other locations. This is apparent from the technological analyses discussed above and from the simple observation of artifact density: Stud 2 has nearly six times the density of Stud 1. Based on this result, it may be valid to question whether density alone is not a sufficient mechanism for gauging the relative intensity and, therefore, duration of occupation. However, two results which seem to run counter to the general trend of increased intensity of occupation at Stud 2 help to illustrate that the relationship between artifact proportions and density is not as simple as it may first appear.

Both the proportion of noncortical to cortical cores and the flake to tool ratios for the three locations provided anomalous results. Stud Systematic, not Stud 2, shows the highest proportion of microcrystalline noncortical cores to cortical cores, and the flake to tool ratio is highest for Stud 2 for both raw materials. On other measures, Stud Systematic shows the lowest intensity of core reduction, so the increased proportion of microcrystalline reduced cores (i.e., those without cortex) compared to less reduced cores (i.e., those with cortex) is surprising. Similarly, Stud 2 shows the most evidence for intensive core reduction. Therefore, it might be expected that this location would also have proportionally more tools relative to flakes, since increased reduction could be correlated with an increase in the proportion of flakes retouched into tools, leading to a reduction in the flake to tool ratio. However, this is not the case as Stud 2 has the highest flake to tool ratio in both materials of the three locations.

Explanations for these anomalies rest on an understanding of the relationship between assemblage composition, occupation duration, mobility, and the economics of stone procurement, use, and discard as a means of deriving place use history. The simple explanation for the relatively high value of the microcrystalline noncortical core to cortical core ratio at Stud Systematic is the high proportion of microblade cores at this location when compared to the others (Table 7).

They account for nearly 20 percent of the cores by number. Since these cores are by their very nature heavily worked, having been extensively shaped to produce the microblades, their presence in a high proportion will affect the noncortical core to cortical core ratio.

A functional explanation for the presence of these microblade cores that involves the repeated use of space in a uniform way seems unlikely given the chronological evidence discussed above. There are few geographic features that could be used to explain why people chose to perform the same activities in the same place during a series of occupations that span close to 2000 years. An alternative is to explain the distribution of these artifacts in relation to the probability of their discard. The microblade cores in the Stud Systematic assemblage are distributed across a large area and are much less clustered than tools such as scrapers and tulas that are concentrated at Stud 2 (Holdaway et al. 2000). Since scrapers and tulas have a relatively low probability of deposition, their location reflects a place where people spent a relatively long period of time, although the number of occupations over which this time was spread cannot be known. Microblade cores are also clustered at Stud 2, but much less so than tulas. In other places in Australia, these cores are associated with locations that have been interpreted as specialized workshops (e.g., Hiscock 1993). Thus, tulas and microblades have a different context of deposition and hence a different temporal probability of discard. This is reflected in their differential density across the Stud Creek Valley. From this perspective, the apparent anomaly in the noncortical to cortical core ratio in Stud Systematic compared to Stud 2 is not an anomaly at all, but a result of the different use of space through time.

The high flake to tool ratio at Stud 2 is surprising, because, if this location was the site of more intensive core reduction, it might be expected that this would be associated with increased tool discard, assuming flakes were produced as blanks for tools. However, the relatively high value for the flake to tool ratio suggests the opposite; relatively few flakes were retouched into tools at this location. There is evidence from other studies (e.g., Dibble 1995) that flake production and tool manufacture may not be uniformly correlated. In assemblages where core reduction dominates, the flake to tool ratio remains high, because a substantial proportion of the flakes are not retouched into tools. Core reduction also leads to the production of relatively high concentrations of shatter compared to the proportion of complete flakes. This seems likely to be the case in Stud Creek assemblages, where, in common with Australian assemblages in general, it is likely that flakes were often used without being retouched.

At the Stud Creek locations, flakes, rather than tools, dominate in all three assemblages. The flake to core ratio shows that for both silcrete groups, Stud 2 saw greater levels of core reduction than at either of the other locations. In this sense, the Stud Creek locations can be ranked according to their relative intensity of core reduction along the lines proposed by Dibble (1995).

The Stud Creek locations were reoccupied for a sufficient duration to lead to the deposition of many flakes, but either occupation was not sufficiently long for the conversion of a high proportion of these flakes into tools, or occupation was not by people who used the flakes in a way that frequently required retouch. Alternatively, or in addition, occupations did not outlast the use-life of the tools and a number were removed before they became exhausted.

Elston (1990) argues that prolonged occupation should lead to greater use of locally available material in preference to material brought from other locations. This will be mitigated by the ease with which imported material can be acquired, something that can not have varied much through time at Stud Creek, given the prevalence of quarries within a few kilometers of the valley (Doelman et al. 2001). At Stud Creek material was readily available but it still required some additional effort to visit the quarries compared to using locally available material from the gibber patches. It seems likely that the Stud 2 location was occupied more often than Stud 1, given the greater density of artifacts and the evidence for increased levels of core reduction at Stud 2. However, it was probably not occupied by groups for substantially longer periods of time. If it had been, we would expect to see increased levels of reduction of local material (i.e., clast silcrete), ultimately leading to a change in the relative proportion of artifacts manufactured in materials brought from elsewhere vs. those knapped from materials immediately at hand. Such a difference does exist among the Stud Creek assemblages, but Stud 2 shows a relatively higher proportion of *material derived from quarries* (i.e., microcrystalline) compared to *local* (i.e., clast silcrete) material than Stud 1. Thus, increased occupation presumably reflects groups using the location more often rather than for longer periods of time.

CONCLUSION

The analysis presented above stands in contrast to a number of recent approaches aimed at understanding the late Holocene settlement systems that characterized arid zone Australia (e.g., Thorley 1998; Veth 1993). In these approaches, site survey forms the basis of analyses that seek to compare the nature of stone artifact assemblages from a wide variety of locations. A chronology is frequently developed by comparing stratified, dated assemblages from rockshelters with the contents of surface assemblages. However no independent checks are undertaken to verify that the chronology of these locations match. Instead, it is assumed, either tacitly or explicitly, that sites recorded during survey were all used as part of a common, effectively synchronous, settlement system where human-environment interaction and surface geomorphology can be characterized as stable. In other words, in studies such as these, change is neglected in exchange for the definition of a stable settlement system often (but not exclusively) tied to the differential availability of water.

As stated above, the results of our dating program at Stud Creek precluded such a synchronic view of human-environment interrelationships for two reasons. First, our geomorphic studies indicated that land surfaces have not been stable in the past. While we can be sure that the assemblages from Stud Creek date to the last 2000 years, the same cannot be said for assemblages on the margins of other drainage systems. Therefore, the assumption that all sites encountered during a survey represent part of a single settlement system seems difficult to sustain, at least in our case. Second, the results of the hearth dates from Stud Creek indicated that for a period the valley was abandoned. Thus, we have direct proof of at least one change in the settlement system of which this valley formed a part, since people stopped using this location for a period of some centuries.

Therefore, instead of undertaking wide-ranging surveys, discovering a number of sites whose age we could not determine, and interpreting these in functional terms, we were forced to search for an alternative method of stone artifact analysis. The result is an analysis that talks of occupation duration of a place measured by the nature and composition of artifact assemblages. At Stud Creek, the dating of hearths indicates that visits were recurring but not particularly regular. The stone artifact analysis indicates something of the nature of these visits. Some places like Stud 2, with concentrations of artifacts, were visited more often, but not necessarily for longer periods than others. Areas of the valley, like that sampled in the Stud Systematic assemblage, were used in ways that suggest less frequent, and less prolonged occupation. All these analyses are relative, in the sense that the uses of the terms more and less refer to comparisons made among the assemblages analyzed. If more analyses were undertaken, the patterns apparent at Stud Creek would need to be reassessed. Obviously it would be desirable to extend these analyses to assemblages from a number of dated locations across a larger study area.

In analyzing the stone artifacts in this way we are not denying that the people who deposited these artifact assemblages used them for a variety of purposes. We do question the utility of studying these if the intention is to determine *the* function performed at a place that has accumulated artifacts from multiple occupations, and then use this functional ascription to link to a synchronic view of land use. The way people used space in the past is an essential aspect of Indigenous Australian prehistory, but one that needs to be developed with approaches like that used at Stud Creek that allow for change.

ACKNOWLEDGMENTS

This project was funded by a Collaborative Australian Research Council (ARC) grant to Simon Holdaway and the NSW National Parks and Wildlife Service, a Small ARC Grant to Simon Holdaway, and a Macquarie University Research Grant to Patricia Fanning. Permission to conduct this study from the Wangkumara Cultural Heritage Management Committee (traditional owners), the Tibooburra Local Aboriginal Land Council and the NSW National Parks and Wildlife Service is gratefully acknowledged. Thanks also to students from La Trobe and Macquarie Universities for their valuable input of labor. This paper has benefited from discussions with Harry Allen, Caroline Bird, Dorothy Brown, Angela Close, David Frankel, Peter Hiscock, Judith Littleton, Tim Murray, Peter Sheppard, Nicola Stern, and LuAnn Wandsnider and from the comments of two anonymous reviewers. Seline McNamee drew the figures.

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ABSTRACT

An analysis of surface scatters of stone artifacts from late Holocene contexts at Stud Creek, Sturt National Park in the northwest of New South Wales, Australia, is reported. A sedimentological and archaeological chronology for Stud Creek shows archaeological remains are no older than 2000 years and Stud Creek saw repeated occupation during the last two millennia. Methods are proposed whereby conflated stone artifact assemblages from different locations within the Stud Creek catchment can be analyzed to understand how use of the catchment differed from place to place. We propose "place use history," as a more useful concept than "settlement system" for understanding surface artifact assemblages. Keywords: arid Australia, hunter-gatherers, late Holocene, lithics.